

Fuel-Flexible Microturbine and Gasifier System for Combined Heat and Power

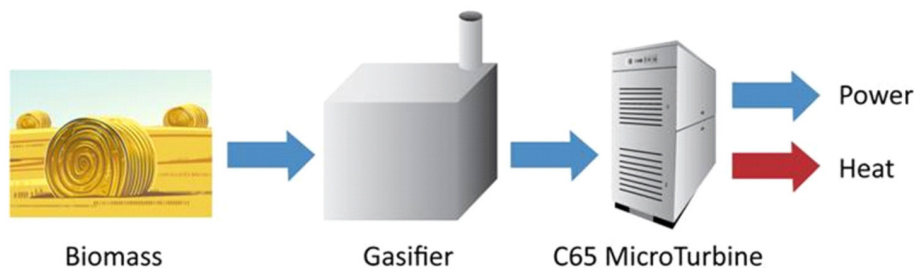
Operating a Gas Turbine CHP System on Syngas from Biomass Gasification

This project will develop and demonstrate a prototype microturbine combined heat and power system fueled by synthesis gas and integrated with a biomass gasifier, enabling reduced fossil fuel consumption and carbon dioxide emissions.

Introduction

The most common fuel used in microturbines is currently natural gas. However, a combination of recent factors, including unstable natural gas prices, actions toward carbon emissions regulation, and excess risk from reliance on a single fuel source, has made the utilization of natural gas substitutes attractive from both environmental and economic standpoints.

One candidate renewable fuel source is biomass. In the biomass gasification process, organic materials such as crop residue are reacted with a controlled amount of oxygen and steam. The output of gasification is called synthesis gas (syngas) which is composed primarily of hydrogen (H) and carbon monoxide (CO).



Schematic showing gasifier/microturbine concept

While syngas is rich in hydrogen, the primary component of natural gas is methane (CH₄). These two fuels combust differently, so a redesigned microturbine combustion system is required before syngas can be used successfully.

This project aims to address this barrier by developing and testing a new gas turbine injector design for use with syngas fuels. The project will also demonstrate a prototype microturbine CHP system integrated with a gasifier.

Benefits for Our Industry and Our Nation

The use of low-carbon, flexible fuels in a clean, efficient, and cost-effective microturbine will provide significant potential reductions in fossil fuel consumption, greenhouse gas and criteria pollutant emissions, and electricity costs.

With rising fertilizer and natural gas prices, farmers are under considerable pressure to improve efficiency and reduce energy costs. A farm could recover an investment in this technology in only 12 months, assuming the farm is paid for the electricity it contributes to the grid at retail rates. Larger operations may achieve an even faster return on their investments.

Potential benefits from a 10-year installed base of microturbine/gasifier systems include:

- Reduction in fossil fuel consumption of 441 trillion Btu/year, or the amount of fuel consumed annually by 6.1 million cars
- Reduction in carbon dioxide (CO₂) emissions of 31 million tons/year, or the amount released annually by 5.4 million cars

Applications in Our Nation's Industry

With 2.1 million farms in the United States, agriculture represents a significant potential market for a microturbine CHP system with an integrated biomass gasifier. Using this novel approach, a farm can utilize crop residue to meet its electricity needs and to provide heat for purposes such as drying grain.

Project Description

The objective of this project is to develop a microturbine system capable of operating on alternative fuels, particularly syngas of various compositions. The project will demonstrate a prototype microturbine CHP system integrated with a biomass gasifier.

Barriers

- Achieving stable combustion without flashback while premixing hydrogen and air to maintain low nitrogen oxide (NO_x) emissions
- Obtaining consistent fuel composition from a gasifier working with variable biomass feedstock

Pathways

The University of California, Irvine (UCI) will assist Capstone Turbine Corporation with fuel injector and combustor designs, and will procure combustion components to be integrated into prototype turbines. UCI will work with Capstone and Argonne National Laboratory (ANL) in the evaluation of fuels and will support field testing.

Packer Engineering is developing a gasifier which will provide syngas for the initial demonstration and evaluation of the integrated system.

Upon completion of turbine prototypes, ANL will prepare a test site and evaluate the performance of the system. ANL will conduct flame visualization and temperature performance measurements in support of combustion analysis.

Milestones

- Creation of concept design, including results from fuel characterization, combustion concept definition, and syngas analysis
- Drafting of preliminary design for the fuel-flexible turbine system, including results from combustion analysis
- Detailed design of turbine system, including injector, combustor, and gasifier
- Testing and evaluating the performance and emissions of a prototype integrated fuel-flexible turbine system, including gasifier

Commercialization

In moving this technology towards commercialization, priority will be placed on achieving ultra-low emissions performance in order to maximize potential market size, including regions with restrictive emissions regulations such as California.

Integration of a syngas-fueled microturbine with a CHP system and a gasifier is only one application of this flexible-fuel technology. As part of this project, the team will define the operating range of fuels for the new fuel system and evaluate other market opportunities for the technology.

The first year sales potential is 5,000 65kW systems. Production rates can ramp up to 10,000 systems per year. This rate of adoption assumes a U.S. market penetration of less than 5% over 10 years. Even this modest level of success has the potential to generate gross revenues of \$3 billion USD.

Project Partners

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December 2009